MARKED-UP VERSION OF ENGLISH TRANSLATION OF INTERNATIONAL APPLICATION AS ORIGINALLY FILED

~~DESCRIPTION~~

ELONGATED MAGNETIC SENSOR

BACKGROUND OF THE INVENTION

1. ~~Technical~~ Field of the Invention

[0001] ~~——~~The present invention relates to elongated magnetic sensors for detecting magnetic patterns printed on, for example, currency bills.

2. Description of the Related Art

~~Background Art~~

[0002] ~~——~~A variety of elongated magnetic sensors have been commercialized as magnetic sensors for identifying objects, such as currency bills and securities, having predetermined magnetic patterns printed thereon with, for example, magnetic ink.

[0003] ~~——~~The structure of a known elongated sensor is illustrated in Figs. 7A-7C. Fig. 7~~. Fig. 7(A)~~ is a plan view showing the magnetosensitive portion ~~part side~~ of the sensor with a cover detached therefrom. Fig. 7~~(B)~~ is a side view showing a long side of the sensor in that state. Fig. 7~~(C)~~ is a side view showing a short side of the sensor in that state. In this example, an elongated magnetic sensor 200 includes a case 1' and magnetoresistive (MR) devices 21A to 21E arranged linearly in the longitudinal direction of the case 1' with no intervals

therebetween. The magnetoresistive devices 21A to 21E include magnetosensitive unitsparts 22A to 22E, respectively. The magnetosensitive unitsparts 22A to 22E each include two magnetosensitive element arrays extending in the longitudinal direction. The elongated magnetic sensor 200 also includes connection electrodes 23A to 23E electrically connected to the magnetosensitive unitsparts 22A to 22E, respectively (three electrodes for each magnetosensitive unit),part); external connection terminals 24A to 24E disposed on the case 1' and connected to the connection electrodes 23A to 23E, respectively,; and a permanent magnet (not shown) disposed on the back surface of the case 1' to apply a magnetic field to the magnetosensitive unitsparts 22A to 22E. The elongated magnetic sensor 200 senses changes in the magnetic field (changes in magnetic flux density) due to a magnetic pattern providedformed on an object being conveyed perpendicularly to the longitudinal direction (in the lateral direction) ofwith the magnetosensitive elements to detect the object (see Japanese Patent No. 2921262 (Patent Document 1)).

[0004] ——Magnetosensitive unitsparts used for such an elongated magnetic sensor each include separate magnetosensitive elements that are combined to achieve larger changes in the resistance of magnetoresistive devices due to changes in the magnetic field, as disclosed in Fig. 4 of Japanese Unexamined Patent Application Publication No. 2003-107142 (Patent Document 2). A magnetosensitive unitpart shown in Fig. 4 of Patent Document 2 includes magnetosensitive elements arranged

longitudinally at intervals, connection conductors electrically connecting the magnetosensitive elements, and terminal electrodes electrically connected to external connection electrodes.

[0005] ~~——~~Fig. 8~~(~~A~~)~~ is an enlarged plan view of the magnetoresistive device 21C of the elongated magnetic sensor 200 shown in Figs. 7A-7C having~~. 7 in the case where it has~~ an inner structure shown in Fig. 4 of Patent Document 2. Fig. 8~~(~~B~~)~~ is a partial plan view showing the arrangement of the magnetoresistive devices 21B to 21D.

~~——~~In Figs. 8A and 8B~~. 8~~, the magnetosensitive unit~~part~~ 22C of the magnetoresistive device 21C includes magnetosensitive elements 221C arranged longitudinally at intervals D1, magnetosensitive elements 222C arranged in parallel with the magnetosensitive elements 221C, connection conductors 223C connecting the magnetosensitive elements 221C in series, and connection conductors 224C connecting the magnetosensitive elements 222C in series. The magnetosensitive unit~~part~~ 22C also includes a terminal electrode 227C electrically connected to an end of the series connection of the magnetosensitive elements 221C through a connection conductor 2251C, a terminal electrode 226C electrically connected to an end of the series connection of the magnetosensitive elements 222C through a connection conductor 2252C, and a terminal electrode 228C electrically connected to the other ends of the series connections of the magnetosensitive elements 221C and 222C through a connection conductor 2253C.

[0006] ~~——~~The magnetoresistive device 21C is disposed

between the magnetoresistive devices 21B and 21D in the longitudinal direction.

~~Patent Document 1: Japanese Patent No. 2921262~~

~~Patent Document 2: Japanese Unexamined Patent Application Publication No. 2003-107142~~

~~Disclosure of Invention~~

~~Problems to be Solved by the Invention~~

[0007] ~~——~~The intervals D1 between the magnetosensitive elements are adjusted so that a detection output produced when a magnetic pattern passes across the intervals D1 is substantially~~nearly~~ the same as that produced when the magnetic pattern passes across the magnetosensitive elements. However, the intervals D2 between the magnetosensitive elements nearest the contact surfaces of the adjacent magnetoresistive devices (in Fig. 8~~(B)~~, for example, the interval between the magnetosensitive elements of the magnetosensitive unit~~part~~ 22C nearest the magnetosensitive unit~~part~~ 22D and the magnetosensitive elements of the magnetosensitive unit~~part~~ 22D nearest the magnetosensitive unit~~part~~ 22C) are greater~~larger~~ than the intervals D1. The magnetosensitive units~~parts~~ cannot be extended to the ends of the magnetoresistive devices because a wafer defining ~~serving as~~ a mother board for the magnetoresistive devices is separated into the magnetoresistive devices by dicing or laser cutting. That is, predetermined cutting margins are defined so as not to cut the magnetosensitive units.~~parts.~~ In addition, the connection conductors are disposed~~formed~~ at the ends of the magnetosensitive

element arrays in the longitudinal direction. Even if the magnetoresistive devices are disposed with the longitudinal ends thereof in contact with each other, the intervals between the magnetosensitive elements nearest the opposite ends of the adjacent magnetosensitive elements cannot be lessnarrower than the areas used for the cutting margins and the connection conductors. When a magnetic pattern passes across the intervals D2, therefore, the elongated magnetic sensor 200 may exhibit a significant decrease in detection output and thus fail to detect the magnetic pattern.

SUMMARY OF THE INVENTION

[0008] To overcome the problems described above, preferred embodiments ~~Accordingly, an object~~ of the present invention ~~is to~~ provide an elongated magnetic sensor which achieves~~capable of achieving~~ a stable detection output at any position thereof in the longitudinal direction.

~~Means for Solving the Problems~~

[0009] ~~——~~An elongated magnetic sensor according to a preferred embodiment of the present invention includes magnetoresistive devices arranged in the longitudinal direction thereof, each including a magnetosensitive unit~~part~~ having magnetosensitive elements arranged at intervals in the longitudinal direction and connection conductors connecting the magnetosensitive elements in series. The intervals between the magnetosensitive elements disposed at the opposite ends of the

adjacent magnetoresistive devices in the longitudinal direction are lesssmaller than or equal to the intervals between the adjacent magnetosensitive elements within each of the magnetoresistive devices in the longitudinal direction.

[0010] When As an object having a magnetic pattern providedformed thereon passes across a surface of the elongated magnetic sensor on which the magnetosensitive unitsparts are disposedformed in the lateral direction, the magnetic pattern varies a magnetic flux passing through the magnetosensitive unitsparts to change the resistance of the magnetosensitive elements. The adjacent magnetosensitive elements within each of the magnetoresistive devices are arranged in such intervals that a detection output produced when the magnetic pattern passes across the intervals is substantiallynearly equal to, or only slightly lesslower than, a detection output produced when the magnetic pattern passes across the magnetosensitive elements. The intervals between the magnetosensitive elements nearest the opposite ends of the adjacent magnetoresistive devices are lesssmaller than or equal to the intervals between the adjacent magnetosensitive elements within each of the magnetoresistive devices. Accordingly, the elongated magnetic sensor experiences very little decrease in detection output when the magnetic pattern passes across the contact portions of the adjacent magnetoresistive devices. The magnetosensitive elements may be disposed in proximity to the opposite ends of the adjacent magnetoresistive devices by providingemploying, for example, a

structure as shown in Fig. 2 in which magnetosensitive elements are located~~formed~~ near the ends of magnetoresistive devices in the longitudinal direction, rather than by providing~~employing~~ a structure as shown in Fig. 8~~(A)~~ in which connection conductors are provided~~formed~~ at the ends of magnetoresistive devices in the longitudinal direction.

[0011] Additionally~~ In the present invention, additionally~~, the intervals between the magnetosensitive elements disposed at the opposite ends of the adjacent magnetoresistive devices in the longitudinal direction are preferably substantially equal to the intervals between the adjacent magnetosensitive elements within each of the magnetoresistive devices in the longitudinal direction.

[0012] ~~——~~This structure enables~~allows~~ the elongated magnetic sensor to produce a substantially uniform detection output in the longitudinal direction because the intervals between the magnetosensitive elements of the adjacent magnetoresistive devices in the longitudinal direction are substantially equal to the intervals between the magnetosensitive elements within each of the magnetoresistive devices in the longitudinal direction.

[0013] Additionally~~ In the present invention, additionally~~, the magnetosensitive unit preferably~~part~~ includes first and second magnetosensitive element arrays arranged substantially perpendicularly to the longitudinal direction. The magnetosensitive elements are arranged such that the

locations~~positions~~ of the magnetosensitive elements of the first magnetosensitive element array in the longitudinal direction, when viewed in the lateral direction, differ from those of the magnetosensitive elements of the second magnetosensitive element array in the longitudinal direction.

[0014] With~~In~~ this structure, the magnetosensitive elements are arranged in two arrays such that the locations~~positions~~ of the magnetosensitive elements in the longitudinal direction differ between the two arrays. The intervals between the diagonally adjacent magnetosensitive elements within each of the magnetoresistive devices in the longitudinal direction are less~~smaller~~ than ~~in the case~~ where the magnetosensitive elements of the two arrays are arranged at the same locations~~positions~~ in the longitudinal direction. The intervals between the diagonally adjacent magnetosensitive elements disposed at the opposite ends of the adjacent magnetoresistive devices in the longitudinal direction are~~may be~~ reduced according to the intervals between the adjacent magnetosensitive elements within each of the magnetoresistive devices. This reduces the area that is not covered by the magnetosensitive elements in the longitudinal direction so as to further stabilize the detection output.

[0015] Additionally~~ In the present invention, additionally~~, the connection conductors are preferably not disposed~~formed~~ at the ends of the magnetoresistive devices in the longitudinal direction.

[0016] ~~——~~In a known~~common~~ structure, each magnetoresistive

device includeshas conductors providedformed at the ends thereof in the longitudinal direction to connect a magnetosensitive unitpart to terminal electrodes adjacent to either long side of the magnetoresistive device and to connect magnetosensitive elements to each other. In contrast, in the structure described above, by contrast, each magnetoresistive device includeshas no connection conductors at the ends thereof because terminal electrodes are disposed adjacent to both sides of the magnetoresistive device in the longitudinal direction. As a result, the magnetosensitive elements are providedcan be formed in regions where connection conductors would be providedformed in the known structure to minimize the intervals between the magnetosensitive elements disposedformed at the opposite ends of the magnetoresistive devices. Accordingly, the overall pitch of the magnetosensitive elements iscan be reduced to stabilize the detection output.

~~Advantages~~

[0017] ~~——~~According to preferred embodiments of the present invention, the intervals between the magnetosensitive elements nearest the opposite ends of the adjacent magnetoresistive devices are lesssmaller than or equal to the intervals between the adjacent magnetosensitive elements within each of the magnetoresistive devices. The elongated magnetic sensor does not exhibit a substantialexhibits little decrease in detection output when a magnetic pattern passes across any region of the elongated magnetic sensor in the longitudinal direction. The elongated

magnetic sensor ~~can~~ therefore stably and reliably detects a magnetic pattern on an object being conveyed in the lateral direction.

[0018] Additionally, according~~According~~ to various preferred embodiments of the present invention, ~~additionally,~~ the magnetosensitive elements are preferably arranged in two arrays such that the locations~~positions~~ of the magnetosensitive elements in the longitudinal direction differ between the two arrays. The elongated magnetic sensor ~~can~~ therefore produces a more stable detection output in the longitudinal direction with reduced intervals between the adjacent magnetosensitive elements in the longitudinal direction.

[0019] Additionally, according~~According~~ to various preferred embodiments of the present invention, ~~additionally,~~ the connection conductors are not provided~~formed~~ at the ends of the magnetoresistive devices in the longitudinal direction. As a result, the intervals between the magnetosensitive elements located~~formed~~ at the opposite ends of the magnetoresistive devices are~~can be~~ reduced such ~~so~~ that the elongated magnetic sensor produces~~can produce~~ a more stable detection output.

[0020] Other features, elements, steps, characteristics and advantages of the present invention will become more apparent from the following detailed description of preferred embodiments of the present invention with reference to the attached drawings.

~~Brief Description of the Drawings~~BRIEF DESCRIPTION OF THE DRAWINGS

[0021] Figs. 1A-1C show ~~Fig. 1 shows~~ a perspective view, a plan view, and a side view of an elongated magnetic sensor according to a first preferred embodiment of the present invention.

[0022] Figs. 2A and 2B show~~Fig. 2 shows~~ an enlarged plan view of a magnetoresistive device 11C of the elongated magnetic sensor shown in Figs. 1A-1C~~. 1~~ and a partial plan view showing the arrangement of magnetoresistive devices 11B to 11D.

[0023] ~~——~~Fig. 3 is a partial plan view showing the arrangement of magnetoresistive devices 11B to 11D of an elongated magnetic sensor according to a second preferred embodiment of the present invention.

[0024] Figs. 4A and 4B show~~Fig. 4 shows~~ an enlarged plan view of a magnetoresistive device 11C of an elongated magnetic sensor according to a third preferred embodiment of the present invention and a partial plan view showing the arrangement of magnetoresistive devices 11B to 11D.

[0025] ~~——~~Fig. 5 is a partial plan view showing the arrangement of magnetoresistive devices 11B to 11D of an elongated magnetic sensor according to a fourth preferred embodiment of the present invention.

[0026] Figs. 6A and 6B show~~Fig. 6 shows~~ an enlarged plan view of a magnetoresistive device 11C of an elongated magnetic sensor according to another embodiment and a partial plan view

showing the arrangement of magnetoresistive devices 11B to 11D.

[0027] Figs. 7A-7C show ~~Fig. 7 shows~~ a plan view and side views of a known elongated magnetic sensor.

[0028] Figs. 8A and 8B show ~~Fig. 8 shows~~ an enlarged plan view of a magnetoresistive device 21C shown in Fig. 7A and a partial plan view showing the arrangement of magnetoresistive devices 21B to 21D.

~~Reference Numerals~~

~~1, 1', and 1'': case~~

~~11A to 11E and 21A to 21E: magnetoresistive device~~

~~12A to 12E and 22A to 22E: magnetosensitive part~~

~~120C and 120C': magnetosensitive element array~~

~~121B, 122B, 121C, 122C, 121D, 122D, 221C, and 222C: magnetosensitive element~~

~~123C, 124C, 1251C to 1254C, 223C, 224C, and 2251C to 2253C: connection conductor~~

~~126C, 127C, 128C, 129C, 226C, 227C, and 228C: connection terminal~~

~~13A to 13E and 23A to 23E: connection electrode~~

~~14A to 14E and 24A to 24E: external connection terminal~~

~~100 and 200: elongated magnetic sensor~~

~~Best Mode for Carrying Out the Invention~~ DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0029] ~~——~~An elongated magnetic sensor according to a first preferred embodiment of the present invention will now be

described with reference to Figs. 1A-2B~~1 and 2~~.

[0030] ~~——~~Fig. 1~~(~~A~~)~~ is a plan view of the elongated magnetic sensor according to this preferred embodiment. Fig. 1~~(~~B~~)~~ is a side view showing a long side of the elongated magnetic sensor. Fig. 1~~(~~C~~)~~ is a side view showing a short side of the elongated magnetic sensor. These drawings illustrate the elongated magnetic sensor with a cover for covering a surface on which magnetoresistive devices are arranged being detached therefrom.

[0031] ~~——~~In Figs. 1A-1C~~. 1~~, an elongated magnetic sensor 100 includes a case 1 and magnetoresistive (MR) devices 11A to 11E arranged linearly in the longitudinal direction of the case 1. The magnetoresistive devices 11A to 11E include magnetosensitive units~~parts~~ 12A to 12E, respectively, with the longitudinal direction thereof being ~~in~~ parallel with that of the magnetoresistive devices 11A to 11E. The elongated magnetic sensor 100 also includes connection electrodes 13A to 13E extending from ends of the magnetoresistive devices 11A to 11E, respectively, in the lateral direction thereof (three electrodes for each magnetoresistive device) and external connection terminals 14A to 14E protruding from the back surface of the case 1 (opposite the surface on which the magnetoresistive devices 11A to 11E are provided~~formed~~) and having a predetermined length (three terminals for each magnetoresistive device). The connection electrodes 13A to 13E and the external connection terminals 14A to 14E are arranged in the longitudinal direction. The connection electrodes 13A to 13E are electrically connected

to the external connection terminals 14A to 14E, respectively; for example, the three connection electrodes 13A are connected to the three corresponding external connection terminals 14A. A groove (not shown) is provided~~formed~~ in a region on the back surface of the case 1 opposite the magnetoresistive devices 11A to 11E. A permanent magnet (not shown) is disposed in the groove to apply a predetermined magnetic field to the magnetosensitive units~~parts~~ 12A to 12E.

[0032] ~~——~~The structure of the magnetoresistive devices 11A to 11E is now~~then~~ described with reference to Figs. 2A and 2B.~~. 2.~~ The magnetoresistive device 11c is herein described as an example because the magnetoresistive devices 11A to 11E preferably have the same structure.

[0033] ~~——~~Fig. 2~~(~~A~~)~~ is an enlarged plan view of the magnetoresistive device 11C of the elongated magnetic sensor 100 shown in Figs. 1A-1C.~~. 1.~~ Fig. 2~~(~~B~~)~~ is a partial plan view showing the arrangement of the magnetoresistive devices 11B to 11D.

[0034] ~~——~~In Figs. 2A and 2B~~. 2~~, the magnetoresistive device 11C includes magnetosensitive elements 121C and 122C arranged longitudinally at the same intervals D1. The locations~~positions~~ of the magnetosensitive elements 121C and 122C are different in the lateral direction~~laterally~~ but are aligned in the longitudinal direction.~~longitudinally.~~ The adjacent magnetosensitive elements 121C are connected in series through connection conductors 123C. The magnetosensitive elements 121C

are connected in a meandering pattern with the intervals therebetween to define~~form~~ a first magnetosensitive element array 120C. The magnetosensitive elements 121C at the ends of the magnetoresistive device 11C in the longitudinal direction are electrically connected to terminal electrodes 126C and 127C through connection electrodes 1251C and 1252C, respectively. The terminal electrodes 126C and 127C are disposed~~formed~~ outside the first magnetosensitive element array 120C in the lateral direction (on the top side thereof in Figs. 2A and 2B~~. 2~~). The terminal electrode 126C is connected to one of the outer connection terminals 13C while the terminal electrode 127C is connected to the inner connection terminal 13C.

[0035] ~~——~~The adjacent magnetosensitive elements 122C are connected in series through connection conductors 124C. The magnetosensitive elements 122C are connected in a meandering pattern with the intervals therebetween to define~~form~~ a second magnetosensitive element array 120C'. The magnetosensitive elements 122C at the ends of the magnetoresistive device 11C in the longitudinal direction are electrically connected to terminal electrodes 128C and 129C through connection electrodes 1253C and 1253C, respectively. The terminal electrodes 128C and 129C are disposed~~formed~~ outside the second magnetosensitive element array 120C' in the lateral direction (on the bottom side thereof in Figs. 2A and 2B~~. 2~~), that is, on the side opposite the terminal electrodes 126C and 127C. The terminal electrode 128C is connected to the inner connection terminal 13C while the terminal

electrode 129C is connected to the other outer connection terminal 13C.

[0036] ~~——~~The outermost magnetosensitive elements 121C of the first magnetosensitive element array 120C and the outermost magnetosensitive elements 122C of the second magnetosensitive element array 120C' are disposed~~formed~~ in the vicinities of the ends of the magnetoresistive device 11C in the longitudinal direction. Specifically, the outermost magnetosensitive elements of the magnetosensitive element arrays are disposed~~formed~~ in the vicinities of the ends of the magnetoresistive device 11C in the longitudinal direction with consideration given to the cutting accuracy with which a wafer is cut into the magnetoresistive devices. As a result, the intervals between the magnetosensitive elements disposed~~formed~~ at the opposite ends of the adjacent magnetoresistive devices are less~~can be smaller~~ than in conventional devices, ~~the known art,~~ that is, in the case where connection conductors are provided~~formed~~ at the ends of magnetoresistive devices in the longitudinal direction.

[0037] ~~——~~The magnetoresistive devices 11A to 11E ~~thus formed~~ are arranged in the longitudinal direction of the case 1 such that the intervals D2 between the opposite magnetosensitive elements of the adjacent magnetoresistive devices (in Fig. 2~~(B)~~, the interval between the magnetosensitive element 121B of the magnetoresistive device 11B and the magnetosensitive element 121C of the magnetoresistive device 11C and the interval between the magnetosensitive element 121C of the magnetoresistive device 11C

and the magnetosensitive element 121D of the magnetoresistive device 11D) correspond to ~~agree with~~ the intervals D1 between the magnetosensitive elements within each magnetoresistive device (e.g., the magnetoresistive device 11C). Accordingly, the magnetosensitive elements of the magnetoresistive devices 11A to 11E are arranged at the same intervals D1 (= D2) in the longitudinal direction.

[0038] ——The operation of the elongated magnetic sensor 100 is described below.

[0039] ——As an object having a magnetic pattern printed thereon, such as a currency bill, is conveyed in the lateral direction of the elongated magnetic sensor 100, the magnetic pattern passes near the surface of the elongated magnetic sensor 100 on the magnetoresistive device side. The magnetic pattern on the object then varies the magnetic field of the permanent magnet to change the density of the magnetic flux passing through the magnetosensitive elements located~~positioned~~ in the region where the magnetic pattern passes. The resistance of the magnetosensitive elements changes in response to the change in the flux density. The elongated magnetic sensor 100 senses the change in resistance to detect the magnetic pattern. For example, the external connection terminals 14A to 14C are connected to positive voltage terminals, grounding terminals, and negative voltage terminals such~~so~~ that the elongated magnetic sensor 100 senses the change in the resistance of the magnetosensitive elements according to the change in the current passing through

the terminals to detect the magnetic pattern.

[0040] ——In the structure described above, all magnetosensitive elements are ~~can be~~ disposed at regular intervals across the ends of the magnetoresistive devices 11A to 11E to produce a substantially constant detection output irrespective of where the magnetic pattern passes in the longitudinal direction of the elongated magnetic sensor 100. That is, the elongated magnetic sensor 100 does not suffer from~~can avoid~~ problems in the known art, including a significant decrease in detection output resulting between magnetoresistive devices and a time difference in detection output between magnetoresistive devices.

[0041] ——Accordingly, an elongated magnetic sensor is ~~can be~~ provided which ~~can~~ stably and reliably detects a magnetic pattern irrespective of, for example, where the magnetic pattern is disposed ~~formed~~ on an object.

[0042] ——Next, an elongated magnetic sensor according to a second preferred embodiment of the present invention will be described with reference to Fig. 3.

[0043] ——Fig. 3 is a partial plan view showing the arrangement of the magnetoresistive devices 11B to 11D of the elongated magnetic sensor according to this preferred embodiment.

[0044] ——For the elongated magnetic sensor shown in Fig. 3, the intervals D2 between the opposite magnetosensitive elements of the adjacent magnetoresistive devices are less~~smaller~~ than the intervals D1 between the magnetosensitive elements within each

magnetoresistive device. The rest of the structure is the same as the elongated magnetic sensor according to the first preferred embodiment of the present invention.

[0045] ~~——~~This structure prevents~~can prevent~~ a decrease in the detection output produced when a magnetic pattern passes between the opposite ends of the adjacent magnetoresistive devices relative to that produced when the magnetic pattern passes across the magnetoresistive devices. If the intervals D2 are much less~~extremely smaller~~ than the intervals D1, a larger detection output is produced when a magnetic pattern passes across the intervals D2, that is, between the adjacent magnetoresistive devices, than when the magnetic pattern passes across the magnetoresistive devices. In that case, the magnetic pattern may be detected by controlling the detection output produced in the intervals D2. Therefore, the elongated magnetic sensor ~~can therefore~~ reliably detects the magnetic pattern.

[0046] ~~——~~In the structure according to this preferred embodiment, the intervals D2 between the opposite magnetosensitive elements of the adjacent magnetoresistive devices are less~~smaller~~ than the intervals D1 between the magnetosensitive elements within each magnetoresistive device. Unlike the first preferred embodiment, the intervals D2 do not necessarily have to correspond to ~~agree with~~ the intervals D1, such~~so~~ that the magnetoresistive devices can be easily ~~readily be~~ arranged. While regular intervals, as in the first preferred embodiment, may be difficult to precisely define between

magnetoresistive devices in actual manufacturing processes, the structure according to the second preferred embodiment can be relatively easily ~~be~~ achieved because slight errors such as intervals D1 that are greater than~~>~~ intervals D2 are permissible.~~allowable.~~ The second preferred embodiment can therefore provide a higher yield of elongated magnetic sensors than the first preferred embodiment.

[0047] ~~——~~That is, the second preferred embodiment allows the production of elongated magnetic sensors without decreasing the yield thereof due to ~~in case of~~ an error associated with an arrangement step in manufacturing processes.

[0048] ~~——~~Next, an elongated magnetic sensor according to a third preferred embodiment of the present invention will be described with reference to Figs. 4A and 4B~~. 4~~.

[0049] ~~——~~Fig. 4~~(~~A~~)~~ is an enlarged plan view of the magnetoresistive device 11C of the elongated magnetic sensor according to this preferred embodiment of the present invention. Fig. 4~~(~~B~~)~~ is a partial plan view showing the arrangement of the magnetoresistive devices 11B to 11D.

[0050] ~~——~~For the magnetoresistive device 11C of the elongated magnetic sensor according to this preferred embodiment, as shown in Figs. 4A and 4B~~. 4~~, the locations~~positions~~ of the magnetosensitive elements 121C of the first magnetosensitive element array 120C are different in the longitudinal direction from those of the magnetosensitive elements 122C of the second magnetosensitive element array 120C'. Specifically, the

magnetosensitive elements 122C are disposed at locations~~positions~~ corresponding to the centers between the adjacent magnetosensitive elements 121C. The magnetosensitive elements 121C and 122C, which are diagonally adjacent with respect to the longitudinal direction, are arranged at intervals D3 in the longitudinal direction. The intervals D3 are less~~smaller~~ than the intervals D1 in the first and second preferred embodiments. The diagonally opposed ~~opposite~~ magnetosensitive elements of the adjacent magnetoresistive devices (e.g., the diagonally opposed ~~opposite~~ magnetosensitive elements 122B and 121C of the magnetoresistive device 11B and 11C and the diagonally opposed ~~opposite~~ magnetosensitive elements 122C and 121D of the magnetoresistive device 11C and 11D) are arranged at intervals D4 equal to the intervals D3. The remainder~~rest~~ of the structure is the same as the elongated magnetic sensor according to the first preferred embodiment of the present invention.

[0051] ~~——~~The elongated magnetic sensor having the structure described above ~~can~~ reliably detects a magnetic pattern irrespective of where the magnetic pattern passes, as in the first preferred embodiment of the present invention. In addition, the elongated magnetic sensor produces~~can produce~~ a more stable detection output because the intervals between the magnetosensitive elements in the longitudinal direction are less~~smaller~~ than those in the first preferred embodiment, and thus, the area that is not covered by the magnetosensitive elements is reduced in the longitudinal direction.

[0052] ——Next, an elongated magnetic sensor according to a fourth preferred embodiment will be described with reference to Fig. 5.

[0053] ——Fig. 5 is a partial plan view showing the arrangement of the magnetoresistive devices 11B to 11D of the elongated magnetic sensor according to this preferred embodiment of the present invention.

[0054] ——For the elongated magnetic sensor according to this preferred embodiment, as shown in Fig. 5, the intervals D4 between the diagonally opposed ~~opposite~~ magnetosensitive elements of the adjacent magnetoresistive devices are less~~smaller~~ than the intervals D3 between the diagonally adjacent magnetosensitive elements within each magnetoresistive device. The remainder~~rest~~ of the structure is the same as the elongated magnetic sensor according to the third preferred embodiment of the present invention.

[0055] ——The elongated magnetic sensor having the structure described above has the same advantages as in the third preferred embodiment and can be produced without decreasing yield due to ~~in case of~~ an error associated with manufacturing processes, as in the second preferred embodiment of the present invention.

[0056] ——Although the magnetosensitive units are arranged~~parts are formed~~ in a meandering pattern in the preferred embodiments described above, they may also be arranged~~formed~~ in a linear pattern in the longitudinal direction, as shown in Fig. 6.

[0057] Figs. 6A and 6B~~Fig. 6~~ shows enlarged plan views of

an elongated magnetic sensor in which the magnetosensitive element arrays 120C and 120C' of the magnetosensitive units are arrangedparts are formed in a linear pattern. Fig. 6(A) is an enlarged plan view of the magnetoresistive device 11C. Fig. 6(B) is a partial plan view showing the arrangement of the magnetoresistive devices 11B to 11D.

[0058] ——For the elongated magnetic sensor, the magnetosensitive unitpart 12C includes the first magnetosensitive element array 120C, in which the magnetosensitive elements 121C and the connection conductors 123C are alternately connected in the longitudinal direction, and the second magnetosensitive element array 120C', in which the magnetosensitive elements 122C and the connection conductors 124C are alternately connected in the longitudinal direction. The intervals D6 between the opposed opposite magnetosensitive elements of the adjacent magnetoresistive devices are lesssmaller than or equal to the intervals D5 between the magnetosensitive elements within each magnetoresistive device. The remainderrest of the structure is the same as the elongated magnetic sensor according to the first preferred embodiment of the present invention.

[0059] ——This structure has the advantage of stably and reliably detecting a magnetic pattern irrespective of where the magnetic pattern passes, as in the first and second preferred embodiments of the present invention.

[0060] ——The positions of the magnetosensitive elements in the longitudinal direction may differ between the two parallel

magnetosensitive element arrays, as in the third and fourth preferred embodiments. Such a structure has the advantage of more stably detecting a magnetic pattern, as in the third and fourth preferred embodiments of the present invention.

[0061] While preferred embodiments of the present invention have been described above, it is to be understood that variations and modifications will be apparent to those skilled in the art without departing the scope and spirit of the present invention. The scope of the present invention, therefore, is to be determined solely by the following claims.